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(54) IMPROVEMENTS IN OR RELATING TO FIRE PROTECTION MEANS

(71) I, SECRETARY OF STATE FOR DEFENCE, London, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to means for resisting, preventing, damping or quelling, or resisting or preventing the spread, of fire. Such means are hereinafter called fire protection means. The invention is particularly concerned with fire protection in certain bays adjacent fuel tanks or tanks of other flammable substances found in vehicles and craft, especially aircraft. If a bay is penetrated by a projectile, even if not incendiary or if the tank is ruptured in an accident, fuel may leak into the bay and ignite.

According to the present invention there is provided adjacent a flammable substance or a container therefor fire protection means comprising an encased and sealed reticulated structure as herein defined containing an extinguishant.

The extinguishant may be a fluid such as a gas, a liquid, or a particulate substance. Suitable gases include carbon dioxide, bromotrifluoromethane (BTM), bromomethane, or bromochlorodifluoromethane (BCF), of these BTM has a low boiling point and is preferred in aircraft use. The liquid if used, may comprise a foaming substance. It has, however, been discovered that quite small amounts of extinguishant powders such as potassium cryolite, potassium and sodium bicarbonates, and ammonium phosphate, usually when provided with a dispersion or flow additive, can prevent a fuel fire when dislodged and dispersed from the structure. A preferred powder has a mean particle size of less than 60 microns. A suitable dispersion additive is micronised hydrophobic silica.

For the purpose of this specification a reticulated structure is one which displays a net like or cellular appearance in a cross sectional view on at least one plane.

Powder dispersion may be further improved by ensuring that the contents are at a pressure higher than that of the environment in all circumstances of liability to accident, the pressure preferably being obtained with an inert gas such as nitrogen. In an aircraft, the normal environment of which is at a pressure lower than at sea level, a pressure of not much greater than 10% above normal sea level atmospheric pressure may be desired.

According to one aspect of the invention the encased reticulated structure may comprise a reticulated polyurethane ether or ester foam encased in a plastics sheet material such as polystyrene sheet, the co-extrusion of polyvinylidene chloride with low density polyethylene sold by Dow Chemical Ltd under the trade mark 'Saranex' a film of polyethylene terephthalate, e.g. that sold by ICI Ltd under the trade name 'Melinex', overcoated with polyvinylidene chloride, or the polyethylene terephthalate based film sold by Dupont Ltd under the trade name 'Mylar'. Such a foam may have about 8—16 preferably about 10, pores per linear centimetre and a strand thickness of about 0.07—0.4mm.

The reticulated structure may be a metal reticulation, made of, for example, nickel chrome. It is possible to encase such a reticulation in a skin e.g. of synthetic rubber, by arranging for the structure partially to penetrate the skin during manufacture. So-called 'Self sealed' flexible fuel tanks for aircraft may be made of flexible lamination of this type.

The reticulated structure may comprise a reticulated plastics foam as above and wherein each strand is coated with metal such as nickel chrome, or it may comprise a honeycomb structure of metal foil such

as an aluminium laminate or plastics such as a glass fibre reinforced material. The honeycomb walling may also be perforated. These relatively more rigid structures are preferably sealed with a metal skin stuck thereto with an adhesive. The skin may comprise part of the structure of skin of the aircraft. A more rigid structure may be required for example where it is to remain sealed for a very long period of time. This is particularly the case in aircraft bays and the fact that the powder extinguishant requirement is small means that the extra weight associated with a rigid structure may be tolerated.

Fire protection means in accordance with this aspect of the inventon may not be required completely to line the bay; either the wall contiguous with the tank may be unlined, or only that wall may be lined. Furthermore they may form part of the aircraft structure or of the fuel tank wall. In particular, in an arrangement where a backing board is interposed between an aircraft skin/stringer assembly and a fuel tank, flexible or otherwise, which the backboard may serve to support, the backing board may comprise a structure in accordance with the invention. The means may be in the form of briquettes rather than panels, however, where for example, they are to be attached to structure as a retrofit.

It is of course advantageous to arrange the dimensions of the structure to ensure an efficient operation of extinguishant, commensurate with the size of the bay. It will be appreciated that when a honeycomb structure with imperforate walling containing a powder extinguishant is used, rupture of the case is likely to release a limited quantity of the extinguishant compared with a structure which is reticulated in three dimensions. Although this enhances the multishot capability of the structure a structure reticulated in three dimensions such as a reticulated foam will not need to be as thick as a honeycomb structure. A typical perforated metal foil honeycomb structure has a cell size of 10 mm—30 mm and is 10—30 mm thick or more. 22 SWG or thinner aluminium alloy sheet may form a suitable skin. Such a structure can contain an extinguishant gas, such as bromotrifluoromethane, at up to 500 kPa gauge pressure or even more, and is suitable for protecting a bay of up to about 20 cm deep. For a much smaller bay glass fibre reinforced plastics, non-perforate walling honeycomb, with glass fibre reinforced plastics skins, cell size 3—10 mm and 2 mm or more thick, and containing an extinguishant powder, may be adequate.

Fire protection means according to a second aspect of the invention may comprise an elastomeric bag pressurised with a non-combustible gas and containing a resilient reticulated foam pad, the faces of which are secured to the inner surface of the bag.

Preferably the foam pad is of polyurethane ester or polyurethane ether and having a porosity of 4—40, preferably 24, pores per linear cm. and a strand thickness of about 0.075 to 0.4 mm. Such a foam may be 97 per cent void and have a density of about 15—30 Kg/m^3.

The non-combustible gas may be any of those mentioned in paragraph three of this specification. The bag may in addition to the gas contain a quantity of an extinguishant powder such as one of those mentioned in paragraph three of this specification.

The gas is preferably contained at the highest pressure which can be retained over a period of years and is unlikely to promote bursting, e.g. 35—210 kPa gauge.

The faces of the foam pad may, for example, be welded to the inner surface of the bag. However other suitable methods of securing the faces of the pad to the inner surface of the bag which would not cause gas leakage from the bag such as for example a method employing an adhesive could be employed.

The elastomeric bag is preferably made of a low permeability material. By low permeability is meant a permeability to oxygen of less than 40 cc/m^2/24 hours per atmosphere in normal atmospheric conditions. A suitable bag may be fabricated of 'Saranex' (TM), Melinex' (TM) with a polyvinylidene chloride overcoat, or Mylar (TM). These films have a typical permeability of 0.2 cc/m^2/24 hrs per atmosphere to BTM and BCF. The skin may be 0.025—0.05 mm thick. An adhesive of the epoxy resin type may be employed to stick the skin to the foam.

Fire protection means according to this second aspect of the invention may be made by securing the faces of the foam pad to the inner surface of the bag, pressurising the bag with incombustible gas through an aperture in the bag and closing the aperture. Any other suitable method for making fire protection means according to the invention such as, for example, by spraying on the foam pad a substance which hardens to form an elastomeric bag adhering to the faces of the foam pad and then pressurising the bag with incombustible gas through an aperture in the bag and closing the aperture, may be employed.

Fire protection means according to a third aspect of the present invention may comprise a ball of resilient reticulated foam having a skin of elastomeric material and containing a non-combustible gas.

The foam and skin may comprise any of those listed in respect of the second aspect

of the invention. The gas may be any of those mentioned in paragraph three of the specification. A powder such as one or more of those described in paragraph three of the specification may additionally be installed. The skin may adhere to the foam and the ball may be pressurized to 30—210 kPa gauge. The foam ball, which may be from 2—15 cm in diameter may additionally be hollow.

The elastomeric skin may adhere to the foam, and preferably has as low a permeability as possible.

Balls according to this third aspect of the invention can readily be poured into and removed from spaces between aircraft fuel tanks and their surrounding structure. In the event of penetration of some of these balls and the tank by an incendiary projectile the activity of gas, and powder if used, and the lack of air around or restriction of the passage of air to it may prevent the outbreak of fire. If a fire does start further balls will be opened and their extinguishant applied to the fire.

In fire protection means according to a fourth aspect of the present invention the encased and sealed reticulated structure is constituted by a compartmented bag, the compartments containing a fire protection substance.

The compartments may have walls of low permeability material and contain a fluid extinguishant i.e. a liquid, a powder or a gas at pressure such as any of the liquid, powder or gaseous extinguishants hereinbefore described.

The compartments may be formed by distinct containers such as closed tubes, capsules, sachets, or balls such as those described hereinbefore. The containers are preferably made of a low permeability material such as the copolymer of isobutylene and isoprene in film form, Saranex (trade mark) or Mylar (trade mark). On the other hand the compartmented bag may be formed integrally with its compartment walls in the same material, the preferred material being a low permeability fabric, for example woven glass fibre textile or nylon yarn fabric proofed with a synthetic rubber such as polychloroprene or polyurethane synthetic rubber. The exterior of the bag may be coated with a hardwearing material such as neoprene, so that the finished bag may have low permeability and high resistance to fuel and fretting. In one embodiment the bag is formed of butyl rubber coated with neoprene.

In another embodiment of this fourth aspect of the invention the compartments are filled with a plastics foam material which will itself act as an extinguishant or flame suppressant. Preferred foams include polyurethane ether or ester foams, having a density of 15—30 kg/m³ and a porosity of about 20 to 28 pores per linear cm. Advantageously this foam may be resilient and subject to a compression of 5 to 15% in the compastment so that the path bored by a projectile may be rapidly closed in behind the projectile. On the other hand the foam may be reticulated foam and be permeated with an extinguishant substance, such as one of the fluid extinguishants hereinbefore described. The gas, if used, may be pressurised to 30—210 kPa gauge. In either case the foam may be stuck to the compartment walls with an adhesive.

The bags may be provided with means associated with each compartment permitting emptying and/or recharging with fluid extinguishant.

In a bag in accordance with a fifth aspect of the invention the encased and sealed reticulated structure may comprise a sealed bag made of a non-rigid, possibly fabric reinforced, plastics material having a cross stitching of 2 to 5 threads per cm extending across the cavity between faces of the bay, and containing a non-combustible gas under pressure.

Bags in accordance with the invention may be formed to correspond with the space between a tank in an aircraft and surrounding aircraft structure, and may thus be from 2—10 cm thick. The bag is preferably attached to the outer wall of the tank, perhaps with an adhesive or mechanically. An incendiary projectile likely to pierce a tank, where there is danger of a fire outside the tank but within aircraft structure, should penetrate such a bag first. The contents of the penetrated compartment or compartments will prevent or restrict ignition or explosion of flammables in/or escaping from the tank.

Examples of fire protection means in accordance with the present invention will now be described with reference to the accompanying drawings, of which:

Figure 1 is a section through a fire protection slab, according to the first aspect of the invention,

Figure 2 is a diagrammatic section through an aircraft wing showing fire protection slabs of the type shown in Fig. 1 in position,

Figure 3 is a section through fuel tank walls made of flexible fire protective means according to the first aspect of the invention,

Figure 4 is a section through an aircraft backing board in situ and made of fire protection means according to the first aspect of the invention,

Figure 5 shows a honeycomb structure bag in accordance with the fourth aspect of the invention,

Figures 6, 7 and 8 show bags containing tubes,

Figure 9 shows a bag containing sachets,
Figure 10 shows a sachet,
Figure 11 shows a bag containing balls, and
Figure 12 shows a bag containing reticulated foam.

In the example shown in Figure 1 a 2 cm thick slab 10 of polyurethane ether reticulated foam having 10 pores per linear cm (ppcm) and a strand thickness of 0.25 mm, is coated with 'Saranex' (TM) 11 which is stuck to the slab with an adhesive. The slab is vacuum back filled with 'Monnex' (TM). which is a potassium bicarbonate/urea reaction product with a dispersion additive sold by Imperial Chemical Industries, and sealed.

The dimensions, shape and curvature of slabs of the type illustrated in Fig. 1 may be predetermined in accordance with the size and curvature of the walls of the bay in which they are to be fitted and the extent to which they are likely to be subject to airflow. Usually it will be preferred to attach them to the tank face. Where they are to be attached to bay walls it may be possible to use the walls as part of the encasement of the fire protection means, or indeed to use the first protection means as part of the structure. The construction shown in Figure 2 is an aircraft wing 20 having a fuel tank 21 located between the spars 22 and 23. The bays 24 and 25 fore and aft of the spars 22 and 23 respectively are protected with fire protection slabs 26 such as those of the example above. If a projectile passes through one of these bays into the tank or if the tank and structure are otherwise ruptured extinguishant will be dispersed in the bay and it is a feature of the invention that slabs as thin as 3 mm thick overall can contain sufficient extinguishant to douse a fire in a bay 15 cm wide, when the projectile incendiary and fuel is leaking into the bay.

Figure 3 shows part of a flexible fuel tank wall comprising a 6 mm thick layer of nickel chrome reticulation 30 with 35 ppcm and a strand thickness of about 0.25 mm, embedded in 3 mm thick synthetic rubber sheet 31 to a depth of about 1.5 mm, impregnated with potassium cryolite powder to a depth of 3 mm and the remaining 1.5 mm embedded in a further 3 mm thick synthetic rubber sheet 32. The powder has a mean particle size of about 30 microns and includes micronized hydrophobic silica as a dispersion agent.

Figure 4 shows an aircraft skin 40 supported by stringers 41. The stringers 41 also support an aircraft backing board 42 which in turn supports a flexible fuel tank 43. The backing board 42 comprises a 5 mm thick core 44 in the form of a glass fibre reinforced plastics honeycomb with transverse bores 5 mm across the flats, the core being stuck to a 30 SWG thick sheet 45 of glass fibre reinforced plastics material, filled with P11-24 which is the trade name of an ammonium phosphate based powder sold by Pierrefitte-Auby of Paris. The honeycomb is then sealed with adhesive to another 30 SWG thick sheet 46 of glass fibre reinforced plastics material. An alternative honeycomb is that made of high temperature resistant polyamide in paper form and sold by CIBA-Geigy (UK) Ltd under the Trademark 'Aeroweb Nomex'.

In the examples of Figures 3 and 4 the core is pressured to 20 kPa gauge. Thus if a projectile penetrates the core in either case, or if a wall sealing is otherwise ruptured the release of pressure from the core will enhance the dispersion of the powder therein.

An alternative structure, suitable for use in situations such as those illustrated in Figure 2, employs perforated wall aluminium alloy honeycomb 20 mm cell size and 20 mm thick sealed with 22 SWG aluminium alloy and containing bromotrifluoromethane at a pressure of 400 kPa.

An example of fire protection means in accordance with the second aspect of the invention includes a reticulated polyurethane ether foam pad having a porosity of 24 ppcm, a strand thickness of about 0.13 mm and a density of 25 kg/m^3 in the normal, untensioned, state. The foam pad is inserted into a Saranex (RTM) bag and the faces of the pad welded to the bag walls. The bag is then pressurised to 175 kPa with BTM gas through a tube inserted into the bag. The bag is then sealed.

A particular example of fire protection means in accordance with the third aspect of the invention comprises a 5 cm diameter ball of reticulated polyurethane ether foam having a porosity of 24 ppcm a strand thickness of about 0.12 mm and a density of 25 Kg/cm^3 0.05 mm thick film of 'Saranex' (trade name) is stuck to the ball with an epoxy resin adhesive by a current wrapping techniqce. The ball is filled with BTM gas to a pressure of about 105 kPa gauge, by evaporation then back filling and sealing.

There now follows some examples of bags in accordance with the fourth aspect of the invention. The bag illustrated in Fig. 5 comprises four layers of fabric 50 attached each one to the next so that upon inflation with nitrogen the bag becomes a honeycomb structure of tubes 51. The fabric is woven nylon proofed with polychloroprene and the joints are made substantially impermeable also. The tubes 11 are inflated to 210 kPa gauge.

The bag illustrated in Fig. 6 is made of lightly proofed nylon fabric, and contains

discrete tubes 52 made of isobutylene-isoprene and covered with glass fibre fabric 53.

The bags illustrated in Figs. 7 and 8 are made of glass fibre fabric 54 proofed with polyurethane synthetic rubber and the bags are compartmented by unproofed fabric in Fig. 7 and proofed in Fig. 8. Each compartment contains a tube 55 made of isobutylene-isoprene.

In Figs. 9 and 11 are shown bags 56 containing respectively sachets 57 and balls 58 of extinguishant. The bags are made of a nylon fabric lightly proofed with polychloroprene. The sachets 57 (see Fig. 10) are made of Saranex (TM) tube ready-filled with nitrogen at a pressure of about 210 kPa gauge so that the complete sachet will contain the gas at a pressure of about 300 kPa gauge, the sachets being formed by a process involving pressing, welding and cutting the tube at discrete stages. The ends of each sachet are fitted with clips 59. The balls 58 may be made of Saranex (TM) also.

The compartmented bag 60 shown in Fig. 12 contains in each compartment a block of resilient polyurethane ester foam 61 having a density of 16 kg/m^3 and a porosity of 24 ppcm. The foam is emplaced on a mandrel so that when in situ it is compressed 10%. The bag is made of butyl rubber coated with neoprene.

A similar bag 60 to that shown in Fig. 12 made of 0.4 mm welded Mylar (TM) contains in each compartment a block of reticulated polyurethane ether foam 61 having a density of 16 kg/m^3 and a porosity of 20 pores per linear cm. The foam is coated with adhesive and emplaced by compressing it on a mandrel and feeding it into its compartment, removing the mandrel and curing the adhesive. Each compartment is then filled with nitrogen gas at a pressure of about 200 kPa gauge and sealed by welding.

Bags of the type illustrated are attached to the wall of the tank they are to protect, either with a suitable adhesive or mechanically. If, in use, an incendiary projectile penetrates the bag and the tank the fire protection substance acts with respect to flammable substance leaking from the tank and to the incendiary device to prevent or restrict the fire.

In the case of the bag illustrated in Figure 12, on passage through it of a projectile within the normal range size and shape of small arms fire the foam closes behind the projectile to leave a minimum of space which could form a combustion chamber for a fire. The foam itself prevents adequate air and fuel getting to a fire and acts as a flame barrier and a blast protector.

A bag in accordance with the fifth aspect of the invention (not illustrated) is made of fabric lined and reinforced neoprene having a cross-stitching of nylon threads at 4 threads per inch between the faces and filled with BTM at 50 kPa. This bag is attached to fuel tank walling in an adjacent compartment, adhesively or mechanically. A projectile of up to 3 cm diameter passing through the bag has been found consistently to gather a hank of stitching and with it to plug the hole it makes in the fuel tank wall.

It will be appreciated that the tank with which the invention may be employed need not be a fuel tank, although a fuel tank can be the most likely seat of a fire. Other flammables include certain hydraulic fluids and oils. Nor need use of the invention be confined to aircraft. Ships and land vehicles and static installations may be protected in this way.

The use of fire protecting balls has been described in UK. Patent Specification Application No. 17231/72 (Serial No. 1,454,492), which claims, contained external to and contiguous with a container for a flammable substance, fire protection means comprising a plurality of balls each supporting a fire protection substance.

With regard to the embodiment described with respect to Figure 12, U.K. Patent Specification Application No. 25236/72 (Serial No. 1,454,494) claims first protection means, external to and contiguous with a container for a flammable substance, comprising an elastomeric bag compressing a resilient foam pad contained therein.

WHAT I CLAIM IS:—

1. Adjacent a flammable substance or a container therefor, fire protection means comprising an encased and sealed reticulated structure as hereinbefore defined, containing an extinguishant.

2. Fire protection means according to Claim 1 and wherein the extinguishant is a fluid.

3. Fire protection means according to Claim 1 or Claim 2 and wherein the extinguishant is a powder.

4. Fire protection means according to any one of Claims 1 to 3 and wherein the reticulated structure includes a reticulated plastics foam.

5. Fire protection means according to any one of Claims 1 to 3 and where the reticulated structure is a honeycomb structure.

6. Fire protection means according to Claim 5 and wherein the honeycomb walling is perforated.

7. A backing board comprising sub-

stantially rigid fire protection means according to any one of the preceding claims.

8. A container whose wall is made of fire protection means according to any one of Claims 1 to 6.

9. Fire protection means according to Claim 4 and wherein the structure is encased in an elastomeric bag adhering thereto and the extinguishant is a gas with which the bag is pressurised.

10. Fire protection means according to Claim 9 and wherein the bag also contains an extinguishant powder.

11. Fire protection means according to any one of Claims 4, 9 and 10 and in the form of a ball.

12. Fire protection means according to any one of Claims 1 to 3 and in the form of a compartmented bag.

13. Fire protection means according to Claim 1, and wherein the seated reticulated structure is constituted by a compartmented bag, and wherein the extinguishant is a plastics foam material.

14. Fire protection means according to Claim 13, and wherein the foam material is under compression.

15. Fire protection means according to Claim 14 and containing also a fluid extinguishant under pressure.

16. Fire protection means according to any one of Claims 13 to 15 and wherein the foam material is stuck to the walls of the compartments with an adhesive.

17. Fire protection means according to Claim 5 and comprising glass-fibre reinforced plastics honeycomb with a cell size of 3—10 mm and a thickness of 2—10 mm, filled with a powder extinguishant and sealed with at least one glass-fibre reinforced plastics sheet.

18. Fire protection means according to Claim 17 and wherein the powder is pressurized.

19. Fire protection means according to Claim 6 and wherein the honeycomb and the sealing walls are of metal and the cell size and thickness are each 10—30 mm, and the honeycomb contains an extinguishant gas under pressure.

20. Fire protection means substantially as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.

21. Fire protection means substantially as hereinbefore described with reference to Figure 3 of the accompanying drawings.

22. Fire protection means substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.

23. Fire protection means substantially as hereinbefore described with reference to any one of Figures 5, 6, 7, 8 and 12 of the accompanying drawings.

24. Fire protection means substantially as hereinbefore described with reference to Figures 9 and 10 of the accompanying drawings.

25. Fire protection means substantially as hereinbefore described with reference to Figure 11 of the accompanying drawings.

26. Fire protection means substantially as hereinbefore described in any of the examples.

27. Fire protection means according to claim 1 and comprising a sealed bag made of non-rigid plastics material having a cross-stitching of 2—5 threads per centimeter extending across the bag cavity between faces and containing a non-combustible gas at a pressure above normal atmospheric pressure.

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Agent for the Applicant.

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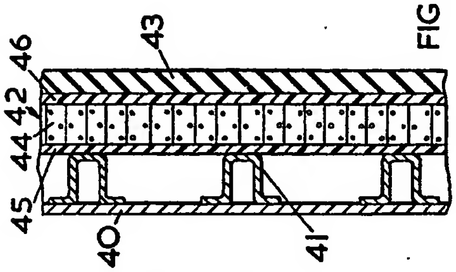

FIG. 4.

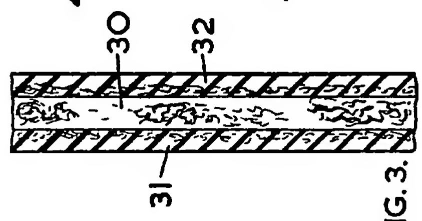

FIG. 3.

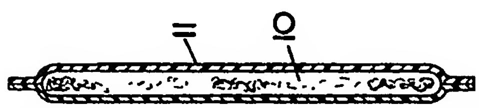

FIG. 1.

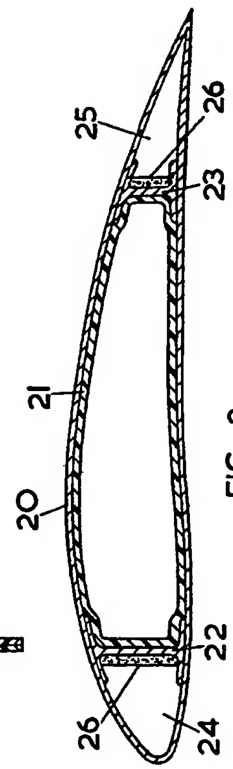

FIG. 2.

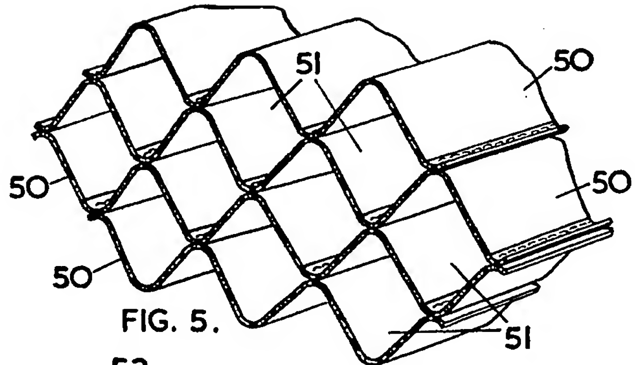

FIG. 5.

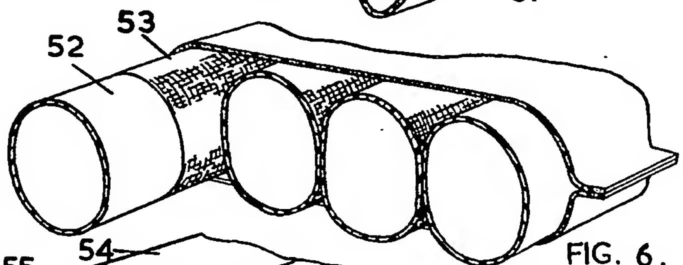

FIG. 6.

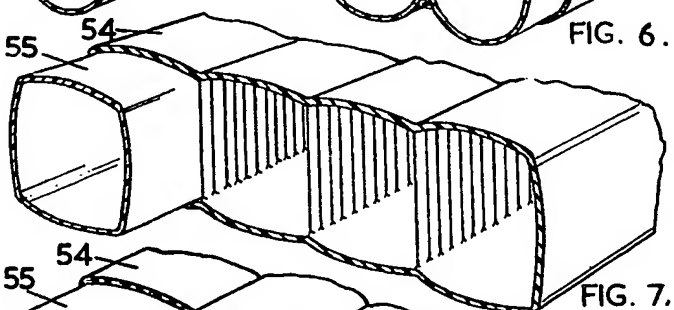

FIG. 7.

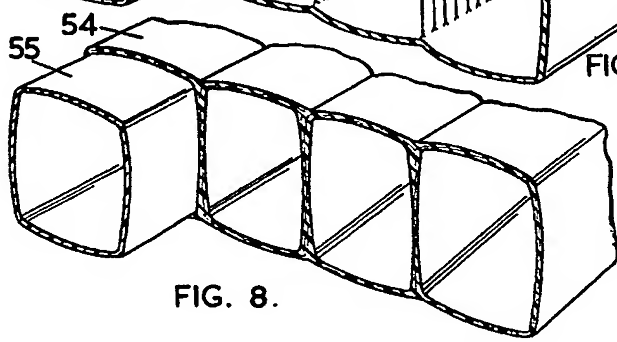

FIG. 8.

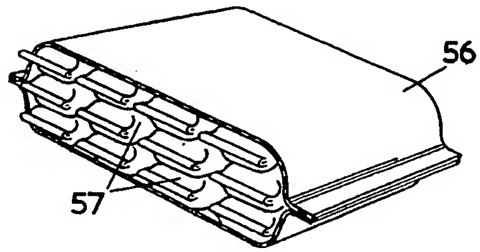

FIG. 9.

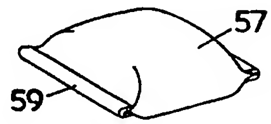

FIG. 10.

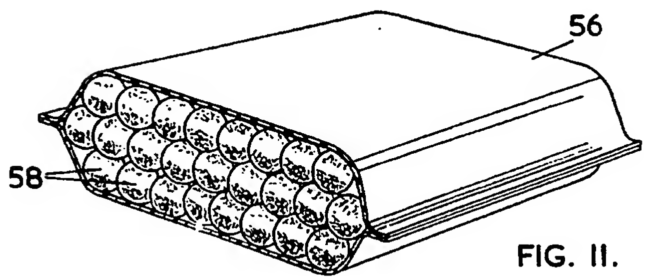

FIG. 11.

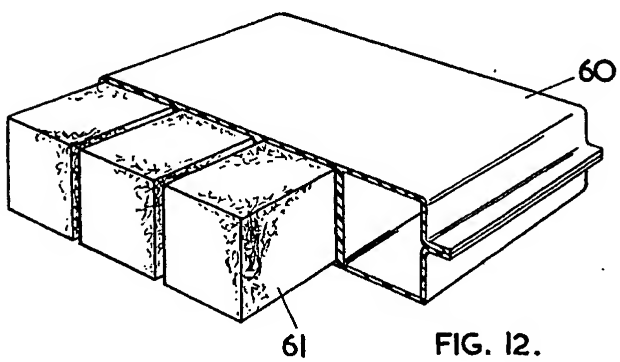

FIG. 12.